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THE UTC-PAB/AGARD STRES BATTERY: USER'S MANUAL & SYSTEM DOCUMENTATION

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13. ABSTRACT *(Maximum 200 words)*
This report provides test installation and administration procedures and system documentation for the UTC-PAB/AGARD STRES Battery Version 3.1. This document serves as a user's manual for the test modification of the programs. Seven standardized tests were constructed as specified by the AGARD AMP-Working Group 12. This version of the STRES battery was constructed to be compatible with the Unified Tri-Service Cognitive Performance Assessment Battery and System. An executive program allows the tests to be administered individually or as a battery. Subject data are automatically updated with each successive test run. Tests items are presented in a pseudo-random fashion for repeated-measures research designs. Accuracy and response time are recorded on an individual item basis, data files are formatted for easy transfer to a variety of statistical analysis packages, and a summary STRES battery was designed primarily for use in stress research with human subjects, but potential applications far exceed this initial purpose. This test battery should prove useful in laboratories interested in a broad spectrum of cognitive research.

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FORWARD

The advent of microprocessor-based performance assessment systems has opened exciting opportunities for research and application. The first generation of these systems was a direct translation of paper and pencil or discrete component systems. The second generation has begun to take advantage of the unique flexibility of the modern micro-computer and represents a powerful toolset that is within the means of most investigators. Now, a third generation is under development that will fully exploit multimedia, high-resolution, dynamic stimulus arrays and extended response capability.

The UTC-PAB/AGARD STRES Battery can be usefully thought of as a solid, conservatively designed assessment tool that is an excellent representative of the second generation of assessment instruments. Component tests are well-documented in the literature. The realizations of the tests in hardware and software are of laboratory quality with respect to such issues as timing accuracies, psuedo-random sequencing, et cetera. The design of the test configuration and administration interface has benefitted from many painful lessons learned.

We believe that this package will be widely useful in research that requires cross-reference with the work of others. We are committed to the development and maintenance of the normative data bases required to support such work. Multicenter, multicultural studies are scientific and administrative challenges that can approach the nightmarish in difficulty. The UTC-PAB/AGARD STRES Battery provides a solid benchmark that will facilitate the design, conduct, and interpretation of such studies.

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Assessment Technology
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SUMMARY PAGE

THE PROBLEM

This report provides test installation and administration procedures along with system documentation for the Unified Tri-service Cognitive Performance Assessment Battery/Advisory Group for Aerospace Research and Development (UTC-PAB/AGARD), Standard Tests for Research with Environmental Stressors (STRES) Battery Version 3.1. The purpose of this document is to serve as a user's manual for this particular edition of this test battery. In addition, technical detail regarding the software is provided to allow modification of the programs.

FINDINGS

The Naval Aerospace Medical Research Laboratory, under the sponsorship of the Office of Military Performance Assessment Technology, has constructed seven standardized tests as specified by the (AGARD) Aerospace Medical Panel (AMP)-Working Group 12. This version of the STRES battery was constructed for compatibility with the Unified Tri-service Cognitive Performance Assessment Battery and System. A specially designed executive program allows the tests to be administered individually or as a battery in which subject data are automatically updated with each successive test run and test items are presented in a pseudorandom fashion for repeated-measures research designs. Accuracy and response time are recorded as individual items, data files are formatted for easy transfer to a variety of statistical analysis packages, and summary statistics are automatically processed for each test.

RECOMMENDATIONS

The UTC-PAB/AGARD STRES battery was designed primarily for use in stress research with human subjects, but potential applications far exceed this initial purpose. This test battery should prove useful in research laboratories interested in a broad spectrum of cognitive research.

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1. INSTALLATION AND ADMINISTRATION PROCEDURES

OVERVIEW

The UTC-PAB/AGARD STRES Battery includes a series of programs that correspond to the specifications defined by AGARD AMP WG-12 (1). These include software for seven tests that are presented in a menu-driven system. According to the specifications established by WG-12, the tests should be administered in the following fixed order:

Reaction Time
Mathematical Processing
Memory Search
Spatial Processing
Unstable Tracking
Grammatical Reasoning
Dual-Task (Unstable Tracking with Concurrent Memory Search)

Version 3.1 software has been designed so that the battery may be administered in its entirety during one automated session or started at a specified test in the menu and then run to completion. An option is also available that allows each test to be run individually. The programs were written in C on Zenith model Z-248 microcomputers operating MS-DOS 3.1 or above.

INSTALLATION

Turn on the computer and follow the instructions listed below.

1) The UTC-PAB/AGARD STRES BATTERY software resides on two floppy diskettes that are labeled Disk 1 and Disk 2. Insert disk 1 into drive A:.

2) Create a subdirectory on the hard drive (i.e., drive C:). This is where the battery will reside. For our example, the subdirectory is called STRES, but the name can be anything you choose. To create the subdirectory, type the letters MD (make directory) followed by a space and the name of the subdirectory.

EXAMPLE:
Type MD STRES
Press <ENTER>.

3) Type A:. Press <ENTER>. This changes the DOS prompt to A:.

4) Type the word INSTALL followed by a space, then type C:\ and the name of the new subdirectory and press <ENTER>.

EXAMPLE:
To install into the "C:\STRES" subdirectory
Type INSTALL C:\STRES
Press <ENTER>.

5) After the files from disk 1 have been installed, the following message is displayed:

Insert Executables and Support Files (disk 2)
Strike any key when ready...

When this "strike any key" message appears, remove disk 1 from drive A:, insert disk 2 and press <ENTER>.

6) When the installation is finished, remove disk 2 and store both diskettes in a safe place. The authors recommend that copies be made of the original diskettes.

7) Type C, press <ENTER>.
Type CD\STRES, press <ENTER>.

This sets the current directory to the STRES subdirectory where the battery now resides. In our example, the screen display will say C:\STRES. If a C: prompt is displayed without the name of the new subdirectory, type the letters CD, followed by a space and the subdirectory's name, and then press <ENTER>.

BATTERY SETUP

After installing the battery, run the setup program, which consists of three distinct sections: Miscellaneous, Response Keys, and Task Selection and Ordering. The Miscellaneous section allows the selection of various system-specific parameters, such as the type of randomization to be used by each program, and the type of hardware in use. These parameters are common to all programs started from the menu. The Response Key Definition section allows the selection of response keys. The Task Selection and Ordering section creates the file that is used by the "MENU" program to control which tests to execute and in which order.

To run the setup programs, type SETUP and press <ENTER>. An introductory screen is displayed with the message "STRES BATTERY SETUP." In addition, an instruction at the bottom of the screen reads "Press ENTER to continue" ("ex" to exit). Press <ENTER>. The screen will now display the Main Menu and indicate that a selection should be made from the menu list.

Miscellaneous Settings and Parameters

This section prompts for selection of a variety of parameters and displays "current" or "default" values in "< >." Pressing <ENTER> only at any given prompt retains the default or current value as displayed. Typing in a new value updates the one that currently exists. Press <ENTER> for all items that are to remain the same. Type the new values for items that require modification and press <ENTER>.

Select menu item 1, MISCELLANEOUS.
Type 1
Press <ENTER>.

1) After selecting option 1, the screen will display "Miscellaneous" and request "Path for setup data." This option permits storage of setup data in an alternate subdirectory or drive. The default leaves the setup in the current subdirectory along with the rest of the battery and is appropriate for most situations. Press <ENTER>.

2) The next option to be displayed is "Random stimulus generation type." This requires the selection of how the test item order is to be determined. Options include (1) fixed (the order of the test items never changes during repeated administrations but is based on the value of n, e.g., fixed 3); (2) session (the order of test items is "pseudo-random based on a "seed number" set by the session number during repeated testing; and (3) random (test-item order is truly random on each successive administration). In our example, we will select the default option (i.e., session) and press <ENTER>.

3) The "I/O board type" designation is next. In our example, we will select the Tecmar option, and type Labmaster and press <ENTER>.

4) "Interrupt number" pertains to technical information that is found in the manuals that come with the I/O boards. Check the setting, type it in, and press <ENTER>.

5) The "I/O board starting port address" option is next.

Type 0280
Press <ENTER> for the SRL Labpak
or
Type 0710
Press <ENTER> for the Tecmar Labmaster.

6) Next, designate the "Monitor type" (e.g., CGA, EGA or SIGMA 400) by typing the letters that correspond to the type of monitor that is being used and press <ENTER>. For a VGA monitor, select the EGA option.

7) The final option is to designate whether or not to "Save incomplete (i.e., partial) data" sets. Type either save or no save for the desired option and press <ENTER>. Saving partial data prevents the loss of all data for the current task if the test is abnormally terminated.

After all options have been defined, the values are displayed for verification. If any are incorrect, press <n>, and the process begins again. Continue until all values are correct, and press <y> at the "Are these correct..." prompt. The "SETUP" program will then return to the main menu screen.

Response Key Definition

From the main menu screen, select the Response Key Definition option (i.e., type 2 and press <ENTER>). This section prompts the user to enter the key for the standard A, B, C, D key positions as defined in the AGARD specifications. The operation of this section is similar to the Miscellaneous section; enter values only if you wish to change the current settings (in "< >"). When finished, answer <y> to the "Are these correct..." prompt, and the main menu screen is displayed.

Test Selection and Ordering

Select the Task Selection and Ordering option from the main menu screen (i.e., type 3 and press <ENTER>). The video screen will now display a menu of nine tests plus a joystick calibration option. This setup option allows the selection and ordering of tests and the calibration program for the joystick.

To create or revise a test list, enter the test numbers in the order they are to be run. As each test is selected, it is highlighted along with the number designating its "order number" in the test menu.

After selecting the last test to be run, press <ENTER> a second time. The "Selected Tasks" screen is displayed along with the tests and the order of selection. If they are correct press <y> for (yes); or if not, press <n> for (no) and go through the selection process again.

The remaining screens for the setup file are "additional" option screens. Defaults have been set to AGARD specifications. To accept the default setting, press <ENTER>. Press <y> to answer the "Is this correct..." query at the bottom of the screen. To modify the standard (default) parameters, refer to and follow the examples presented in the software documentation section (section 4) of this manual.

Possible Errors

After creating the initial setup file, modifications may be made. If modifications are performed the presence of a prior "SETUP" or "MENULIST" file in the setup directory can cause unexpected values to appear as current values (especially if you thought the default values would reappear). This is harmless if the values are changed. The new "SETUP" file will replace the old one.

2. RUNNING THE BATTERY

SPECIFIC INFORMATION

The program aborts and exits to DOS upon receipt of a <CTRL-F1>.

The STRES battery tasks can be run by using the supplied "MENU" program or by calling the programs directly, singly or in groups (from a batch file, for example). This section only describes menu operation. A description of direct program execution may be found in the individual task execution specifications (section 4).

The "SETUP" program must be run before running the STRES battery tasks from the "MENU" program.

ADMINISTRATION

1. The program that runs the battery is the "MENU.EXE" file. To start the battery, type MENU and press <ENTER>, which will cause the "Information 1" screen to be displayed. The screen displays the version of the battery being run (in this case 3.0) and the hardware options selected during the setup procedure. Press <ENTER>.

2. The next screen is titled "Information 2", which provides some background information and lists the tests that are to be administered. Press <ENTER> to go to the next screen.

3. The Main Menu is displayed and includes three options:

   1) Run Tasks (Single, Restart, Entire)
   2) View Data
   EX - Exit

Type 1, press <ENTER>.

4. The Run Information screen displayed will present the following subject and "run" queries listed below. Note: Default options are displayed in brackets "< >" for each of the items listed below. To accept the currently displayed default option, press <ENTER> after each item has been presented.

A. Subject ID <1234> ("EX" to exit): Type in the subject identification (ID) code and press <ENTER>. The ID can be any four digits or letters, or a combination of digits and letters. The only way to exit the program is by typing EX and pressing <ENTER>.

B. (P)ractice or (T)est <T>: At this prompt, type P to receive test instructions and immediate item-by-item feedback on whether answers are correct or incorrect. Selecting T causes the test to be presented without instructions or feedback.

C. Run Number <2>: Type in the run number (i.e., test session number) and Press <ENTER>. NOTE: The "run" or session number automatically increments on normal exit from the menu program (i.e., completion of a test).

D. Dominant Hand (R or L) <R>: Type R if the subject is right-handed or L if the subject is left-handed. For ambidextrous subjects, type the letter that corresponds to the hand used for writing. Press <ENTER>.

E. (P)aused or (C)ontinuous <C>: Type P to pause between tests. During the pause, the computer will display a request to press <ENTER> to begin the next test. When C is typed, the computer automatically loads the next test with no pauses between tests. Press <ENTER> after choosing P or C.

F. Type of run (S)ingle, (R)estart, (E)ntire: Type S and press <ENTER> to run only one test in the battery. The computer asks "which test" in a later query. Type R and press <ENTER> in cases when you are interrupted (e.g., by power failure) during a session, and you desire to resume the test immediately preceding the interruption. The computer now asks, "which test in the battery do you wish to restart?" It then loads that test and permits continuation of the entire battery. Type E and press <ENTER> to run the battery as specified during setup.

G. When entering the information above, the computer displays a summary of the selections and asks, "Are these correct (Y/N/EX)?:" Type the appropriate letter and press <ENTER>. When N is typed, the "Run Information" program allows changes to be made. When Y is typed, the computer loads the battery and administers the tests as specified. Please refer to AGARDograph No. 308 (1) for complete test descriptions and instructions. An abbreviated summary is presented in section 3 of this manual.

DATA FILES

Summary statistics as specified by AGARD WG-12 (1) are automatically computed and saved on the drive and path specified during the setup procedure. The default is drive C:, and data are saved in the same directory or subdirectory where the battery resides. These may be viewed individually using the "View Data" option listed on the Main Menu Screen of the MENU.EXE file. Do the following to view data:

Type MENU
Press <ENTER>
Press <ENTER> twice to pass the introductory screens
Type 2
Press <ENTER>
Type the name of the file to view
Press <ENTER>.

Data files are coded as follows: the first letter is R (for raw data) or S (for summary data); the next four letters are the subject ID; the next letter is a P or T designating a "Practice" or "Test" session; next is a number indicating the "session number" (and pseudo-random number "seed"); and the three letter extension is an abbreviation for one of the tests (e.g., MTH for Mathematical Processing). Thus, S433P1.MTH designates a summary statistic file for subject 433, in practice session number one for the test Mathematical Processing.

To return to the Main Menu, press <ENTER> at the "filename..." prompt.

Raw data files are not automatically saved for all tests because some tests, for example Reaction Time, use a lot of computer memory when saved. To save raw data for each item presented in a given test, follow the guidelines as presented in Section 3. The program software does provide the option to save a listing of stimulus items presented, the subject's response, the correct answer, and the response time (within ± 1 ms) for every test item in every test. Because, this amount of information can overwhelm the computer hard disk space fairly rapidly caution is advised. Check the available hard disk memory often and transfer data files elsewhere as needed. Data sets are written in ASCII format.

3. ABBREVIATED TEST AND DATA-OUTPUT DESCRIPTIONS

The following are abbreviated descriptions of each test. The reader is urged to refer to AGARDograph No. 308 (1) for a more complete background and illustration of the tests. Please note that standardized instructions to the subjects are incorporated in the actual tests. Therefore, they are not duplicated here.

REACTION TIME (reference, AGARDograph No. 308, pp. 11-19)

Digits are presented individually on a monitor. The subject responds to each digit by pressing the appropriate key on the keyboard.

Stimulus response (S-R) mapping is based on a) position of the digit on the screen, either left/right, and b) identity of the digit.

The following task variables are manipulated across trial blocks: stimulus quality, compatibility of S-R mapping, time uncertainty about stimulus onset, and response complexity.

The stimuli used in this task are the numbers 2-5, or a degraded version of these numbers, inscribed in a square. They appear on either the left or right side of the screen. Subject responses involve depression of the W, D, J, and I keys in response to presentation of the stimulus on the video monitor. There are six variations of the procedure. Individual instructions are displayed on the video screen immediately preceding the presentation of each of the 2-min blocks of test items. The stimulus is equally likely to be 2, 3, 4, or 5. It is equally likely to appear on the left or right.

The distance between the left and right stimulus positions is 63 mm center-to-center on a 12-inch video screen. The size of the individual stimulus is 57 by 46 mm including the rectangular frame although larger or smaller video monitors will change this specification.

Test data are collected for 15 min after the practice phase. Six blocks are administered in the following order:

Basic: (stimulus quality normal; presented at regular intervals)
Coded: (stimulus quality varies; presented at regular intervals)
Time Uncertainty: (same as basic except presented at irregular intervals)
Double Responses: (normal stimulus; three key presses required)
Inversion: (normal stimulus; answer with opposite hand)
Basic: (during data collection phase only).

Each trial has the following structure:

Stimulus presented for 1 s;
Screen is blank for 1 s;
Interstimulus interval is 1 s for correct response;
Interstimulus interval is either 1.0 or 1.5 s for incorrect or missing response. The word "error" is shown for 0.5 s of this time.

<u>**Raw Data**</u>

Stimulus Code: digit displayed (2-5); side of screen (0 = right, 1 = left); stimulus quality (0 = highest, 3 = lowest).

Response Code (key identity).
Reaction Time (positive for correct response, negative for incorrect response, zero for no response).
Interstimulus Interval for Time Uncertainty block.

Summary Statistics

Mean Reaction Time (RT) for correct responses.
Standard Deviation (SD) of RT for correct responses.
Number of trials.
Percentage errors (excluding response failures).
Percentage response failures.

MATHEMATICAL PROCESSING (reference, AGARDograph No. 308, pp. 20-24)

Subjects perform two mathematical operations (addition and/or subtraction) on a set of three single-digit numbers (e.g., 5 + 3 - 4 =). Subjects determine whether the answer is greater than or less than five. Each trial is presented in the middle of the screen in a horizontal format.

The subject is instructed to read and calculate from left to right. A key press indicates greater than or less than five. Reaction time (RT) is recorded from stimulus presentation to subject response.

The operators and operands are selected at random except that:

- only the digits 1-9 are used.
- the correct answer may be any number from 1 to 9 except 5.
- greater-than and less-than stimuli are equiprobable.
- cumulative intermediate totals have a positive value working left to right.
- the same digit cannot appear twice in the same problem unless it is preceded by the same operator on each occasion (e.g., +3 and +3 are acceptable, while +3 and -3 are not).
- the sum of the absolute value of the digits in a problem must be greater than 5.

Blocks of trials are 3 min long. Each trial is structured as follows:

- problem is presented in the middle of the screen
- the problem is erased as soon as the subject responds, or if 15 s have elapsed
- the screen is blanked for an interstimulus interval of 3000 to 5000 milliseconds (ms).

Left-handed subjects respond with the W key for "greater-than" and the D key for "less-than." Right-handed subjects use the I key for "greater-than" and the J key for "less-than."

"End of Task" appears in the center of the screen after the final trial.

Raw Data

- composition of the problem
- correct response
- subject response
- error identification (0,1,-)
- reaction time (positive for correct response, negative for incorrect response, zero for no response).

Summary Statistics

- mean of all correct RT's
- SD of all correct RT's
- mean of correct RT's for response '>'
- SD of correct RT's for response '>'
- mean of correct RT's for response '<'
- SD of correct RT's for response '<'
- number of '>' problems completed
- number of '<' problems completed
- percent errors to '>' problems*
- percent errors to '<' problems*
- percent response failures for '>' problems
- percent response failures for '<' problems

* Response failures are not included in the calculation of error rates.

MEMORY SEARCH (reference, AGARDograph No. 308, pp. 24-29)

This task is based on the paradigm described by Sternberg (4). A set of letters (the set to be remembered) is presented on a monitor. Then, a single "probe" letter is presented, and the subject indicates whether the probe letter is part of the memory set. This is done by pressing the appropriate key for "yes" or "no." The memory set is shown once at the beginning of each block. The probes follow.

The Fixed Set procedure is used. This means the same set of letters is used for an entire block. The test is given in two 3-min blocks. Each block uses a unique memory set: Block 1 uses a memory set of two items; Block 2 uses four items.

The memory set letters are selected randomly from all 26 letters of the alphabet. No visually or acoustically confusing letters are included in the same memory set (e.g., M and N, B and D). The memory set is presented horizontally in the middle of the screen with one character space between each letter.

Positive probe letters are equally likely to match any of the memory set letters. Probe letters that do not match are selected with the constraint that no negative probe is similar to any memory set item. The total number of probes varies with the subject's reaction time. The order of presentation of positive and negative probes is randomized. Positive and negative probes have equal probability. Probe letters are shown in the middle of the screen.

Right-handed persons should press W for "yes" and D for "no." Left-handed persons should respond by pressing I for "yes" and J for "no."

The memory set appears until the subject removes it by pressing a key. The screen is blank for 1 s. The first probe letter appears and marks the beginning of the 3-min timed block. Each probe stays on the screen until the subject responds or until 5 s have elapsed. The screen is blank for 1 s until the next probe letter appears.

Raw Data

- each block (2-character and 4-character) has its own data set in the same file. The letters in the memory set and probe set are stored. Stored with the memory set is the length of time (in milliseconds) between the presentation of the set and the subject's depression of the first key
- probe letter
- subject response (Y, N, -)

- error identification (0, 1, -)
- reaction time (RT), coded positive for a correct response, negative for incorrect, and zero for no answer.

Summary Statistics

- memory set
- probe set
- memory set size
- memory set inspection time
- mean of all correct RT's
- SD of all correct RT's
- mean of correct RT's to positive probes
- SD of correct RT's to positive probes
- mean of correct RT's to negative probes
- SD of correct RT's to negative probes
- number of positive probes
- number of negative probes
- percent errors to positive probes*
- percent errors to negative probes*
- percent response failures to positive probes
- percent response failures to negative probes

* Response failures are not included in the calculation of error rates.

SPATIAL PROCESSING (reference, AGARDograph No. 308, pp. 30-33)

On each trial, a pair of four-bar histograms is presented sequentially on the monitor screen. The subject must determine whether the second, "test," histogram is identical to the first, "standard," histogram. The "test" histogram may be rotated either 90 or 270° with respect to the "standard" histogram. The subject responds "SAME" or "DIFFERENT" by pressing the appropriate response key.

Each histogram is comprised of four bars one to six units in height, each unit being 8.5 mm high and 5 mm wide. Adjacent bars are separated by a gap of 5 mm. A line extends along the base of the figure. The height of each bar in a given histogram is determined randomly. No two bars are identical. Note: These specifications vary if monitors have video screens larger or smaller than 12 inches.

- Standard stimulus. The bars rise above a horizontal baseline. The baseline is positioned in the middle of the horizontal axis and 35 mm below its center. The number 1 is positioned with its base 50 mm below the center of the screen.

- Test stimulus. The baseline coincides with the center of the screen. The histogram extends left (90° orientation) or right (270° orientation). The number 2 has its base 45 mm below the center of the screen.

- During a 3-min trial, test stimuli are equally likely to be oriented either 90 or 270°. Test stimuli are equally likely to be the same as or different than the standard. On trials where the standard and test stimuli are different, at least one of the component bars must differ by at least one unit.

The test consists of 3-min blocks composed of trials. Each trial is structured as follows:

- standard stimulus shown for 3 s.
- blank screen for 1 s.

- test stimulus presented until subject presses one of the response keys or 15 s elapse.
- test stimulus is erased and a 1-s intertrial interval occurs.

Practice runs differ from this because feedback is given.

Response keys for right-handed subjects are "J" when the histograms are the same, and "I" when they are different. Response keys for left-handed subjects are "D" for same and "W" for different.

Raw Data

- standard stimulus
- test stimulus
- direction of bars
- subject response
- reaction time (positive for correct response, negative incorrect response, zero for no response).

Summary Statistics

- mean of all correct RT's
- SD of all correct RT's
- mean of correct RT's for response "SAME"
- SD of correct RT's for response "SAME"
- mean of correct RT's for response "DIFFERENT"
- SD of correct RT's for response "DIFFERENT"
- number of "SAME" trials
- number of "DIFFERENT" trials
- percent errors on "SAME" trials*
- percent errors on "DIFFERENT" trials*
- percent response failures on "SAME" trials
- percent response failures on "DIFFERENT" trials

* Response failures are not included in the calculation of error rates.

UNSTABLE TRACKING [references, AGARDograph No. 308, pp. 33-37 and No. 308 Addendum (5)]

A fixed target is presented in the middle of the screen. A cursor that moves horizontally through the target is displayed. The subject attempts to maintain the cursor position in the same location as the target by means of a joystick. The system has a built-in instability that magnifies any movement of the joystick. It becomes increasingly difficult to respond to the velocity as well as the position of the cursor. A good analogy to the cursor movement is seen when trying to balance a ball in the center of a see-saw.

The task begins when the subject has manipulated the joystick to a value of zero. The subject is then given 10 s to gain control of the cursor before data collection commences. Positive and negative values are recorded when the cursor deviates to the right and left of the target, respectively.

The mathematics used to vary the position of the cursor and increase its velocity are expressed in simple terms as:

New Position = (2*Rate+Lambda)* (Old Position)/(2*Rate-Lambda)+Lambda*Gain*
(Stick Input+Last Stick Input)/(2*Rate-Lambda)

where

Rate = 50 Hz
Lambda = 2
Gain = 4.

The faster the subject moves the joystick, the more out of control the cursor goes. The subject is instructed to avoid control losses that occur when the cursor reaches the edge of the screen.

The task lasts for 3 min and ends with the message "End of Task."

Raw Data for each 1-s interval of the task:

- average error
- incidence of control loss (cursor touched the edge of the screen).

<u>Summary Statistics</u>

- the number of control losses
- RMS error score calculated as RMS error = square root ((sum(x)^2)/n) where x = the absolute of deviations from the middle of the screen averaged for each second, and n = 180.

GRAMMATICAL REASONING [references, AGARDograph No. 308, pp. 38-43 & No. 308 (Addendum) (5)]

On each trial, two logical statements are presented along with three symbols:

+ after #
* before +
* + #

The subject's task is to determine whether the two logical statements match in terms of their correctness in describing the sequential order of the three symbols. If both statements accurately describe the order of the symbols, a key is depressed to indicate consistency between the statements and the order of the symbols. If either of the logical statements inaccurately describes the order of the three symbols, a key is depressed to indicate a discrepancy.

Response keys for right-handed persons are "J" (same) and "I" (different). The response keys for left-handed persons are "D" (same) and "W" (different).

During each 3-min testing session, each of 32 test problems are presented in the middle of the screen in a pseudo-random sequence. If the subject completes all 32 problems, the same sequence repeats. Practice trials differ from test trials because they provide feedback on the screen concerning accuracy, and their onset is paced by the subject.

The structure of each experimental trial is as follows:

- present problem in the middle of the screen
- when the subject presses one of the response keys or 15 s elapses, the problem is erased
- a 1-s intertrial interval separates successive stimuli.

<u>Raw Data</u>

- actual stimulus
- correct response

- subject's response
- error identification (0, 1, -)
- reaction time (positive for correct response, negative for incorrect response, zero for no response.

Summary Statistics

- mean of all correct RT's
- SD of all correct RT's
- mean of correct RT's for response "SAME"
- SD of correct RT's for response "SAME"
- mean of correct RT's for response "DIFFERENT"
- SD of correct RT's for response "DIFFERENT"
- number of "SAME" trials
- number of "DIFFERENT" trials
- percent errors on "SAME" trials*
- percent errors on "DIFFERENT" trials*
- percent response failures on "SAME" trials
- percent response failures on "DIFFERENT" trials

* Response failures are not included in the calculations of percent errors.

DUAL TASK (reference, AGARDograph No. 308, pp. 43-46 & No. 308 (Addendum) (5)].

This test is a combination of the Unstable Tracking and Memory Search tests. Both tests are presented the same way as they are when run separately. However, in this task they are presented simultaneously. The subject is instructed to pay equal attention to both tasks. During the first 3-min period, there is a memory set of two items. There is a memory set of four items for the second period.

The screen display is shown in Fig. 25 of AGARDograph No. 308. Memory sets and probe items are presented directly above the center of the tracking target. The base of the letters is 22 mm above the screen center.

The tasks proceed as previously specified within their individual instructions with the following exceptions:

- the cursor is initially centered under software control
- when the subject presses a key to indicate that the memory set has been memorized, the 10-s warm-up period of Unstable Tracking begins
- the memory set remains on the screen for the first 9 s of this period
- after 10 s have elapsed, the first probe item is presented, and the 3-min test begins.

Subjects use the dominant hand on the joystick for tracking. The other hand is placed on the keys used for memory search. Right-handed subjects use the left hand on the "W" key for "yes" if there is a match, and the "D" key for "no." Left-handed subjects use the right hand on the "I" key for "yes" and the "J" key for "no."

Raw Data

Separate sections are created in the data file for each of the individual tasks.

Unstable Tracking. For each 1-s interval:

- average error
- incidence of control loss.

Memory Search.

- probe letter
- reaction time (positive for correct response, negative for incorrect response, zero for no response).

Summary Statistics

Unstable Tracking.

- RMS error score calculated as
- RMS error = square root ((sum(x)^2)/n) where x = the absolute value of deviations from center screen averaged for each second, and n = 180.
- the number of control failures (where cursor touched edge of the screen).

Memory Search.

- memory set
- probe set
- memory set size
- memory set inspection time
- mean of all correct RT's
- SD of all correct RT's
- mean of correct RT's to positive probes
- SD of correct RT's to positive probes
- mean of correct RT's to negative probes
- SD of correct RT's to negative probes
- number of positive probes
- number of negative probes
- percent errors to positive probes*
- percent errors to negative probes*
- percent response failures to positive probes
- percent response failures to negative probes

* Response failures are not included in the calculation of error rates.

4. SOFTWARE DOCUMENTATION AND GUIDELINES ON IMPLEMENTING THE "ADDITIONAL" TEST OPTIONS

During the construction of the UTC-PAB/AGARD STRES battery, it was realized that some experimental designs would necessitate modification of the WG-12 specifications. For example, some researchers may require only one or two tests, and they may need to make the test longer or shorter. As a result, this version of the battery provides additional options to modify tests during the setup procedures.

INSTRUCTION FILES

Instructions are contained in the file "program name.INO." This file can be altered to create instructions in any language or as other changes dictate. Any editor that creates an ASCII file can be used to create these files or make changes. Instructions are displayed one screen at a time. Except for Reaction Time and Spatial Processing, screen page breaks may be inserted by using .page on a separate line at the desired break point in the instruction file.

The following instructions are for inserting the correct response keys in the test instruction screens. IF NO CHANGES ARE NEEDED FOR THE INSTRUCTION FILES, DO NOT DO THIS.

PROGRAM INSTRUCTION FILES

To utilize response keys in the instruction text:

Put the string !A, !B, !C, !D, !S or !N in the instruction text where the appropriate response key should be printed (refer to AGARD manual page 9 for response key definitions):

!A - replaced in instruction text by left middle finger (response key W)
!B - replaced in instruction text by left index finger (response key D)
!C - replaced in instruction text by right index finger (response key J)
!D - replaced in instruction text by right middle finger (response key I)
!S - replaced in instruction text by "SAME" response key !N - replaced in instruction text by "DIFFERENT" response key.

EXAMPLE:
!S - Instruction text same key is !S. The subject sees: Instruction text same key is J.

REACTION TIME TASK

Program: react
Description: Reaction Time--STRES Battery (AGARD) (v 3.1)
Usage: React -h -Fname -Rname -sn -Ckkkk -Sn -Xblocks -Mtype -dtype -Aaddr
Switches:

- h help
- Fname summary data file <default SDATA.RCT>
- Rname raw data file <default no raw data>
- sn block length in seconds <default 120>
- Ckkkk response keys <default WDJI>
- Sn seed for randomization <default 1>
- Xblocks blocks to perform (1-5) <default 123451>
- Mtype monitor type (EGA, CGA, SIGMA400) <default CGA>

- dtype I/O board type (LABPAK, LABMASTER) <default LABPAK>
- Aaddr port address in hex <default 0x0280>

Technical Specifications

Language: Borland International Turbo C V2.0
Linker: Borland International TLINK
Memory Model: Small
Libraries: graphics.lib
hw.lib
stres.lib

Stand-alone Running Instructions

1. The program file "REACT.EXE" and the instruction file REACT.INO must be present in the current directory unless a "path" statement is used. REACT.INO must be present in the current directory unless a "path" statement is used.

2. To run the program:

C:\>CD STRES
C:\STRES>REACT

Specific Information

The Reaction time program uses a text display of 80 X 25 characters resolution for all monitor types. Pseudo-randomization is used in stimulus selection, which is reproducible by using the same seed in the argument line. The seed defaults to one. Responses other than "legal keys" are discarded. An incorrect response is only generated with the wrong response key. It is possible to press "nonlegal keys" and generate a response failure. Answers are recorded and compared with no regard to case.

The REACT switch -X allows specification of the order of the Reaction Time blocks. The AGARD test definition runs six reaction blocks:

1. Basic Block
2. Coded Block
3. Time Uncertainty Block
4. Double Responses Block
5. Inversion Block
1. Basic Block

Switch-X followed by the appropriate test number will run any, all, or a mix of the 5 types of reaction tests. The AGARD task has 6 total tests, with the Basic Block repeated as the last test. There are 6 test slots available after the X switch, although less than 6 reaction time tests may be run. The default (123451) will run the tests in the order listed above.

EXAMPLE:
REACT -X215 will run a Coded Block, a Basic Block, and an Inversion Block.

MATHEMATICAL PROCESSING TASK

Program: Math
Description: Mathematical Processing--STRES Battery (AGARD) (v 3.1)
Usage: Math -h -Qname -Fname -Rname -Tn -sn -px -Hn -Ckkkk -P -Sn -Mtype -dtype -Aaddr
Switches:

- h help
- Qname equation file <default EQUS>
- Fname summary data file <default FSDATA.MTH>
- Rname raw data file <default no raw data>
- Tn timeout in milliseconds <default 15000>
- sn run length in seconds <default 180>
- pS/-pN save/nosave partial data <default S>
- Hn hand selection (0 = right, 1 = left) <default 0>
- Ckkkk response keys <default WDJI>
- P practice mode if present <default no (test mode)>
- Sn seed for randomization <default 0>
- Mtype monitor type (EGA, CGA, SIGMA400) <default CGA>
- dtype I/O board type (LABPAK, LABMASTER) <default LABPAK>
- Aaddr port address in hex <default 0x0280>

Technical Specifications

Language: Borland International Turbo C V2.0
Linker: Borland International TLINK
Memory Model: Small
Libraries: hw.lib
stres.lib

Stand-alone Running Instructions

1. The program file "MATH.EXE" the equations file "EQUS" and the instruction file "MATH.INO" must be present in the current directory.

2. To run the program:

```
C:\>CD STRES
C:\STRES>MATH
```

MEMORY SEARCH TASK

Program: stern
Description: Sternberg Memory Search--STRES Battery (AGARD) (v 3.1)
Usage: stern -h -Qname -Fname -Rname -Tn -sn -px -Hn -Ckkkk -P -Sn -Mtype -dtype -Aaddr
Switches:

- h help
- Qname memory set file <default SET1 for 2-char; SET2 for 4-char>
- Fname summary data file <default SDATA.STN>
- Rname raw data file <default no raw data>
- Tn timeout in milliseconds <default 5000>
- sn run length in seconds <default 180>
- pS/-pN save/nosave partial data <default S>

- Hn hand selection (0 = right, 1 = left) <default 0>
- Ckkkk response keys <default WDJI>
- P practice mode if present <default no (test mode)>
- Sn seed for randomization <default 0>
- Mtype monitor type (EGA, CGA, SIGMA400) <default CGA>
- dtype I/O board type (LABPAK, LABMASTER) <default LABPAK>
- Aaddr port address in hex <default 0x0280>

Technical Specifications

Language: Borland International Turbo C V2.0
Linker: Borland International TLINK
Memory Model: Small
Libraries: graphics.lib
hw.lib
stres.lib

Stand-alone Running Instructions

1. The following must be present in the current directory:

- the memory set files, "SET1" and "SET2," containing the memory and probe set information
- the instruction file, "STERN.IN0"
- the program file, "STERN.EXE"

2. To run the program selecting various options:

```
C:\>CD STRES
C:\STRES>STERN -QSET1 -H0 -FTEST1 -s180
```

This example uses the set file "SET1," a right-handed subject, the output file "TEST1.STN," and runs for 180 s (2 min). Note that the set file, hand selection and run time could have been omitted, since the defaults for these options are "SET1," right-handed subject, and 180-s run length, respectively. Therefore, the following is equivalent to the above:

```
STERN - FTEST1
```

Specific Information

The program aborts on receipt of a <CTRL-BREAK> (or <CTRL-C>). In this case, the data file is not saved, and an empty file may result; however, if <CTRL-F1> is entered, partial data are saved. Control returns to DOS (if the program is run as a stand-alone), or to the controlling program (as in the STRES battery menu program).

The memory set file contains the memory set and probe set combinations, always in pairs, which are used as the sample sets for memory/probe set selection. The file may contain up to 20 memory set/probe set combinations in the following format:

Line 1: Memory set (1)
Line 2: Probe set (1)

Line 3: Memory set (2)
Line 4: Probe set (2)

EXAMPLE:
RI (Memory set 1)
GCHSJMNPZ (Probe set 1)
RIDL (Memory set 2)
GCHSJMNPZAXB (Probe set 2)

SPATIAL PROCESSING TASK

Program: spat
Description: Spatial Processing--STRES Battery (AGARD) (v 3.1)
Usage: spat -h -Fname -Rname -sn -Hn -Ckkkk -P -Nn -Sn -Mtype -dtype -Aaddr
Switches:

- h help
- Fname summary data file <default -FSDATA.SPA>
- Rname raw data file <default no raw data>
- sn run length in seconds <default -s180>
- Hn hand selection (0 = right, 1 = left) <default -H0>
- Ckkkk response keys <default -CWDJI>
- P practice mode if present <default no (test mode)>
- Nn subject instructions (0 = off, 1 = on) <default -N1>
- Sn seed for randomization <default -S1>
- Mtype monitor type (EGA, CGA, SIGMA400) <default -MCGA>
- dtype I/O board type (LABPAK, LABMASTER) <default -dLABPAK>
- Aaddr port address in hex <default -A0x0280>

Technical Specifications

Language: Borland International Turbo C V2.0
Linker: Borland International TLINK
Memory Model: Small
Libraries: graphics.lib
hw.lib
stres.lib

Stand-alone Running Instructions

1. The program file "SPAT.EXE" and the instruction file SPAT.INO must be present in the current directory.

2. To run the program:

C:\>CD STRES
C:\STRES>SPAT

General Information

Spatial processing utilizes a graphics screen with at least 640 X 200 pixel resolution (CGA or EGA). The CGA high-resolution mode is used regardless of the graphics adapter.

Pseudo-randomization is used in stimulus selection, which is reproducible by using the same seed in the argument line. The seed defaults to one. Responses other than "legal keys" are discarded. An incorrect response is only generated with the wrong response key. It is possible to press "nonlegal keys" and generate a response failure. Answers are recorded and compared with no regard to case.

The program will abort on receipt of a <CTRL-C> or <CTRL-BREAK>. The screen will display an "End of Task" message and return to DOS or the controlling program (i.e., AGARD STRES Menu). Depending on where the subject was in the task, data may or may not be saved to disk. A null file will probably be generated.

UNSTABLE TRACKING TASK

Program: track
Description: Unstable Tracking--STRES Battery (AGARD) (v 3.1)
Usage: track -h -c -Gn -Ln -i -Fname -Rname -sn -px -P -Mtype -dtype -Aaddr -In
Switches:

- h help
- c calibrate joystick <default no>
- Gn gain <default 4.0>
- Ln lambda <default 2.0>
- i reverse joystick <default no>
- Fname summary data file <default SDATA.TRK>
- Rname raw data file <default no raw data>
- sn run length in seconds <default 180>
- pS/-pN save/nosave partial data <default S>
- P practice mode if present <default no (test mode)>
- Mtype monitor type (EGA, CGA, SIGMA400) <default CGA>
- dtype I/O board type (LABPAK, LABMASTER) <default LABPAK>
- Aaddr port address in hex <default 0x0280>
- In interrupt for I/O board <default 7>

Technical Specifications

Unstable Tracking (TRACK.EXE) was written in Turbo C, Version 2.0, TASM, Version 1.0, and TLINK (with a large memory model). The standard CGA ROM graphics character set is used so no licensed fonts are required. Refer to the AGARD specifications or program instructions for details on running the task.

Stand-alone Running Instructions

1. The following must be present in the current directory:

   - the instruction file, "TRACK.IN0"
   - the program file, "TRACK.EXE"
   - a calibration file, "JOYSTICK.CAL."

2. Calibrate the joystick so that the program can know the excursion values and therefore be able to calculate the number of pixels per joystick value. To do this, run the combo program as follows:

C:\>CD STRES
C:\STRES>TRACK -c

and follow the instructions. The calibration values are stored in "JOYSTICK.CAL" upon completion.

3. To run the program selecting various options:

C:\>CD STRES
C:\STRES>TRACK -s180 -FTEST1

This example uses the output file "TEST1," and runs for 180 s (3 min).

__Specific Information__

The task consists of a fixed screen (two side markers, and a center marker) and a movable cursor. The object of the task is to keep the movable cursor centered on the screen without touching the side markers. When a side marker is touched, a control loss has occurred, and the cursor is immediately placed in the center position. The cursor moves horizontally according to the equation:

$$P(i) = (2*R + L)*P(i-1) / (2*R - L) + (L*G)*(J(i)+J(i-1))/ (2*R - L)$$

where

R = Sampling rate (default 50 Hz)
L = Lambda (default 2)
G = Gain (default 4)
J(i) = current sampled joystick value, in millimeters (as related to screen position)
J(i-1) = previous sampled joystick value, as above
P(i) = new cursor screen position, in millimeters
P(i-1) = previous cursor screen position, in millimeters.

The values of L and G may be changed by using the appropriate command line parameters. This may be necessary, since the unstable quality of the task depends on sampling noise from the A/D conversion process and may change based on the resolution and quality of the A/D converter in use. The value of P(i) is updated every 20 ms.

The SRL Labpak or Tecmar Labmaster hardware interrupt is used to allow consistent sampling of the joystick, along with accurate cursor updates. The interrupt vector may be changed on the Labpak or Labmaster board, and if so, the "-I" parameter must be used to adjust the interrupt the program expects.

The task runs for 3 min by default. Average error and incidence of control loss data are collected for each second of task execution.

The program aborts upon receipt of a <CTRL-BREAK> or <CTRL-C>. In this case, the data file is not saved, and an empty file may result; however, if <CTRL-F1> is entered, partial data are saved. Control returns to DOS (if the program is run as a stand-alone), or to the controlling program (as in the STRES battery menu program).

GRAMMATICAL REASONING TASK

Program: gram
Description: Grammatical Reasoning--STRES Battery (AGARD) (v 3.1)

Usage: gram -h -Qname -Fname -Rname -Tn -sn -px -Hn -Ckkkk -P -Sn -Mtype -dtype -Aaddr
Switches:

- h help
- Qname relation file <default -QRELS>
- Fname summary data file <default -FSDATA.GRM>
- Rname raw data file <default no raw data>
- Tn timeout in milliseconds <default -T15000>
- sn run length in seconds <default -s180 (max 200)>
- pS/-pN save/nosave partial data <default -pS>
- Hn hand selection (0 = right, 1 = left) <default -H0>
- Ckkkk response keys <default -CWDJI>
- P practice mode if present <default no (test mode)>
- Sn seed for randomization <default -S0>
- Mtype monitor type (EGA, CGA, SIGMA400) <default -MCGA>
- dtype I/O board type (LABPAK, LABMASTER) <default -dLABPAK>
- Aaddr port address in hex <default -A0x0280>

Technical Specification

Language: Borland International Turbo C V2.0
Linker: Borland International TLINK
Memory Model: Small
Libraries: hw.lib
stres.lib

Stand-alone Running Instructions

1. The program file "GRAM.EXE" the relations file "RELS" and the instruction file "GRAM.IN0" must be present in the current directory.

2. To run the program:

- C:\>CD STRES
- C:\STRES>GRAM

Specific Information

Stimulus selection is accomplished in a pseudo-random fashion so that random stimulus presentations may be repeated. The run number from the Menu program or the -S option for a stand-alone run provides the seed. The default seed is 0. There are 32 total stimulus possibilities.

The interstimulus intervals, deadlines for response, and length of stimulus presentation are as presented in the AGARD technical specifications, as are the instructions for running this task.

Valid response keys are selected by the SETUP program when the task is run from the MENU program. If the program is run stand-alone, the response keys can be selected with the -C option. Responses from keys other than the correct keys are discarded. Incorrect responses are only recorded from valid response keys. Response keys are not upper or lower case dependent.

The program may be aborted by typing <CTRL-C> or <CRTL-BREAK>. No data are saved if the program is aborted; however, partial data are saved if <CRTL-F1> is entered.

DUAL TASK (TRACKING WITH CONCURRENT MEMORY SEARCH)

Program: combo
Description: Unstable Tracking/Memory Search--STRES Battery (AGARD) (v 3.1)
Usage: combo -h -c -Gn -Ln -i -Qname -Fname -Rname -Tn -sn -px -Hn -Ckkkk -P -Sn -Mtype -dtype -Aaddr -In
Switches:

- h help
- c calibrate joystick <default no>
- Gn gain <default 4.0>
- Ln lambda <default 2.0>
- i reverse joystick <default no>
- Qname memory set file <default SET1 for 2-char; SET2 for 4-char>
- Fname summary data file <default SDATA.CBO>
- Rname raw data file <default no raw data>
- Tn timeout in milliseconds <default 5000>
- sn run length in seconds <default 180>
- pS/-pN save/nosave partial data <default S>
- Hn hand selection (0 = right, 1 = left) <default 0>
- Ckkkk response keys <default WDJI>
- P practice mode if present <default no (test mode)>
- Sn seed for randomization <default 0>
- Mtype monitor type (EGA, CGA, SIGMA400) <default CGA>
- dtype I/O board type (LABPAK, LABMASTER) <default LABPAK>
- Aaddr port address in hex <default 0x0280>
- In interrupt for I/O board <default 7>

Technical Specification

Dual Task (henceforth referred to as "COMBO.EXE") was written in Turbo C, Version 2.0, TASM, Version 1.0, and TLINK (with a large memory model). The standard CGA ROM graphics character set is used, therefore, no licensed fonts are required.

Link information may be found in the link command file "COMBO.LNK," which is used by the Microsoft Linker to create the executable file.

Refer to the AGARD specification booklet or program instructions for details on running the task.

Stand-alone Running Instructions

1. The following must be present in the current directory:

- the memory set file, such as "SET1"and "SET2,"
- containing the memory and probe set information
- the instruction file, "COMBO.IN0"
- the program file, "COMBO.EXE"
- a calibration file, "JOYSTICK.CAL"

2. The joystick must be calibrated for the program to know the excursion values and calculate the number of pixels per joystick value. To do this, run the combo program as follows and follow the instructions:

```
C:\>CD STRES
C:\STRES>COMBO -c
```

The calibration values are stored in "JOYSTICK.CAL" on completion.

3. To run the program selecting various options:

```
C:\>CD STRES
C:\STRES>COMBO -QSET1 -H0 -FTEST1 -s180
```

This example uses the set file "SET1" a right-handed subject, the output file "TEST1.CBO" and runs for 180 s (3 min). Note that the set file, hand selection, and run time could have been left off, since the defaults for these options are "SET1," right- handed subject, and 180-s run length, respectively. Therefore, the following is equivalent to the above:

```
COMBO -FTEST1
```

Specific Information

The Memory Search task is a Sternberg memory recall in which a set of letters, the memory set, is memorized, and then used to identify whether or not a probe letter is in the memory set (4). The memory set may be of any size up to 26 letters.

The tracking task consists of a fixed screen (two side markers, and a center marker) and a movable cursor. The object of the task is to keep the movable cursor centered on the screen without touching the side markers. When a side marker is touched, a control loss has occurred, and the cursor is immediately placed in the center position. The cursor moves horizontally according to the equation:

$$P(i) = (2*R + L)*P(i-1) / (2*R - L) + (L*G)*(J(i)+J(i-1))/(2*R - L)$$

where

R = Sampling rate (default 50 Hz)
L = Lambda (default 2)
G = Gain (default 4)
J(i) = current sampled joystick value, in millimeters (as related to screen position)
J(i-1) = previous sampled joystick value, as above
P(i) = new cursor screen position, in millimeters
P(i-1) = previous cursor screen position, in millimeters

The values of L and G may be changed by using the appropriate command line parameters. This may be necessary, since the unstable quality of the task depends on sampling noise from the A/D conversion process and may change based on the resolution and quality of the A/D converter in use. The value of P(i) is updated every 20 ms.

The SRL Labpak and Tecmar Labmaster hardware interrupt is used to allow consistent sampling of the joystick, along with accurate cursor updates. The interrupt vector may be changed on the Labpak board, and if so, the "-I" parameter must be used to adjust the interrupt the program expects.

The task runs for 3 min by default. Average error and incidence of control loss data are collected for each second of task execution.

The program aborts upon receipt of a <CTRL-BREAK> (or <CTRL-C>). In this case, the data file is not saved, and an empty file may result; however, if <CTRL-F1> is entered, partial data are saved. Control returns to DOS (if the program is run as a stand-alone) or to the controlling program (as in the STRES battery menu program).

5. HARDWARE AND SOFTWARE REQUIREMENTS

Hardware and general software requirements for the UTC-PAB/AGARD STRES battery are presented in the following paragraphs. Further details concerning hardware requirements may be found in the UTC-PAB Hardware and Software specifications manual (3).

HARDWARE

1. IBM AT or compatible with the following minimums: 8 MHz, 640-kb RAM, 10-Mb hard disk drive, and one 5.25-inch floppy disk drive.

2. CGA compatible video board and color monitor.

3. Systems Research Laboratories (SRL) Labpak multifunction data acquisition board, with a 1-MHz clock. This is a complete data acquisition board, including (but not limited to) a clock module and an A/D module. Note: this board is no longer commercially available, but an alternative is the Tecmar Labmaster, which is available from Scientific Solutions, Incorporated.

4. Analog joystick, with an output voltage range of ± 5 VDC.

5. Cables to connect joystick to the A/D channel 0 of the Labpak or Labmaster.

6. One hardware interrupt vector in the range 2-7 must be available. Our default is interrupt 7, however others may be specified in the software setup.

SOFTWARE

Microsoft MS-DOS operating system, V3.1 or higher.

CONFIGURATIONS TESTED

1. Zenith Z-248 (8 MHz), 640-kb RAM, 40-Mb hard disk, 80287 math coprocessor, SRL Labpak, with Zenith Z-449 EGA board.

2. Same as (1) above, except SRL Labpak with original A/D chip module, Sigma Color 400 video board, and a 20-Mb hard disk.

3. Same as (2) above, except no math coprocessor present.

4. NEC PowerMate 1 Plus (12 MHz and 8 MHz tested), 640-kb RAM, 40-Mb hard disk, SRL Labpak with original A/D chip module, Paradise VGA+ video board, and no math coprocessor.

5. Same as (1) above, except with Tecmar Labmaster board.

REFERENCES

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2. Englund, C.E., Reeves, D.L., Shingledecker, C.A, Thorne, D.R., Wilson, K.P., and Hegge, F.W., *Unified Tri-service Cognitive Performance Assessment Battery (UTC-PAB) I: Design and Specification of the Battery*, Naval Health Research Center, San Diego, CA, NHRC-TR-87-10, 1987.

3. Reeves, D.L., Thorne, D.R., Winter, S.L., and Hegge, F.W., *The Unified Tri-service Cognitive Performance Assessment Battery (UTC PAB) II: Hardware/Software Design and Specifications*, NAMRL Special Report 89-1, Naval Aerospace Medical Research Laboratory, Pensacola, FL, December 1988.

4. Sternberg, S., "Memory Scanning: Mental Processes Revealed by Reaction Time Experiments." *American Scientist*, Vol. 57, pp. 421-457, 1969.

5. AGARDograph No. 308 (Addendum), *Human Performance Assessment Methods*, North Atlantic Treaty Organization, Advisory Group for Aerospace Research and Development, 7 Rue Ancelle 92200 Neuilly sur Seine, France AGARD-AG 308 (Addendum), March 1991.

APPENDIX

The battery presented in this report was sponsored by Office of Military Performance Assessment Technology (OMPAT). Given that our sponsors represent the military research community, it is appropriate that a portion of this document addresses the issues of application of the tests to such research. The following essay fulfills this requirement. It is from a lecture series under the sponsorship of the AGARD Aerospace Medical Panel and the Consultant and Exchange Programme and was presented by one of the authors on 5-6 June 1989 in Downsview (Toronto), Canada, on 12-13 June 1989 in Soesterberg, The Netherlands, and on 15-16 June 1989 in Pratica di Mare (Rome), Italy. Because our laboratory (NAMRL) is an aerospace research laboratory, the essay focuses on that with which we are most familiar.

Summary for AGARD Lecture Series No. 163

APPLICATION OF PERFORMANCE ASSESSMENT METHODOLOGY TO TACTICAL AIR OPERATIONS

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In the AGARD lecture series, WG-12 presented detailed descriptions and demonstrations of computerized tests that are designed to quantitatively measure various aspects of human performance. The purpose of this essay is to convince the audience that those tests have some practical military value and are not just esoteric tools for the research community. I am assuming that many readers are not human performance researchers, but have some responsibility for maximizing human performance in military operations.

Although the tests in the AGARD battery were developed over many years by research scientists specializing in performance testing, do not assume that these tests are too complex to use. Pay careful attention to the lectures and demonstrations provided here, and you may acquire a valuable tool for use in evaluating the detrimental effects of military stressors. In many situations, the use of this tool eliminates the inconvenience of waiting for someone in a research laboratory to provide that data.

Performance testing methodology has now been developed to the point that these problems can be addressed in the contexts of short-term operational mission planning, long-range development of operational doctrine, and human factors engineering of military hardware.

There are two general categories of problems. The first deals with evaluating the effects of stressors on human performance, and then trying to reduce those effects by manipulation of the stressor. The second deals with assessing the fitness for duty of personnel whose performance may have already been degraded by one or more stressors.

In the first case, to evaluate the stressor one would need to expose personnel to the stressor and measure corresponding changes in performance. This activity usually requires the skills of a researcher. The approach is to simulate an operational situation in which the stressor of interest is applied while personnel performance is measured repeatedly. If the data indicate that the stressor is having a detrimental impact on personnel performance, additional studies may be required to develop methods that will reduce these negative effects.

The people most needing these answers are unit commanders who have the responsibility to plan and direct complex missions. Such commanders often rely on their own experience to predict human performance, or they may direct their medical support staff to study the tactical situation and make appropriate recommendations regarding the ability of crews to execute a specific mission.

Commanders frequently ask analogous questions of their engineering and maintenance personnel regarding the capability of military hardware to endure through a particularly stressful mission. Successful military leaders are keenly aware that these two factors, skilled personnel and high performance hardware are very important requirements for gaining and maintaining military superiority. They also know that if performance degrades in either hardware or personnel, tactical superiority can be quickly lost.

I want to compare the methods by which we maximize our hardware capability to the methods we have available to maximize performance of our personnel. As we make that comparison, notice in addition to the initial development cost, military hardware engineers have also devoted considerable resources to developing tools and methods for maintenance personnel to periodically assess the performance of each system component.

Engineers describe their hardware developments in terms of specifications and performance envelopes. These are highly technical quantitative descriptions. We are not able to describe human performance with the same precision, but we have made sufficient progress in human performance assessment methodology that the concept of human performance envelopes could effectively be applied to military operational decision making.

Let us first compare the tools and processes used to develop and maintain hardware with those now available to evaluate the skills of personnel. When engineers design hardware, they are given functional specifications that were prepared by military specialists who tried to anticipate a broad range of mission requirements. These military planners generally prefer that the hardware meets all mission requirements without sacrificing any engineering state-of-the-art capabilities that might ultimately provide a tactical advantage. Personnel selection is frequently based on a similar objective, that is, to recruit people who have a broad range of capabilities and who would be able to meet any mission contingency.

Operational commanders need to know what their hardware is capable of doing, so the engineers test the hardware to its limits and from these data come the performance envelopes that give the operational commander some quantitative guidelines for planning tactical missions. Commanders can usually expect similar performance from multiple units of hardware that were manufactured to the same specifications. In stark contrast, abilities among human operators vary over a wide range even though they may have met the same selection criteria and were trained by similar methods. These commanders also need a quantitative description of human performance envelopes.

We have not been able to provide such precise descriptions because, compared to hardware, human performance is much more labile and unpredictable, and may be affected by a variety of stresses such as work/rest schedules, length of mission, and many environmental factors. This uncertainty in human performance has become even more important in mission planning with modern weapon systems, because the human operator in these systems is often the weakest link. How do we cope with such uncertainty and high variability in human performance? In peacetime exercises, we could restrict ourselves to only those missions that we know can be accomplished well within the performance envelopes of all the crew members. Such limited training would not be realistic, because in real combat, tactical advantage is frequently achieved by stressing both crews and machines to the edges of their performance envelopes.

How then do operational commanders plan for precisely executed missions that demand maximum human performance from both hardware and operating crews? In these situations, operational commanders need reliable methods to assess the effects of specific missions on crew performance. It is just as important to know how and when the crews will suffer critical performance decrements as it is to know the probable failure modes of the hardware systems. To maximize operational capability, the commander must have tools to assess human performance capability as well as to evaluate hardware condition.

To assess the operability of hardware, test equipment has been developed and is used routinely by maintenance personnel. We may now be getting close to having test equipment and protocols to predict human performance decrements and to assess fitness for duty.

Many aspects of military operations induce decrements in performance that jeopardize the mission. In addition to evaluating the stress inducing factors of specific missions, we may need to evaluate the accumulated stress on individuals. In sustained operations, these performance testing methods would allow

commanders and medical personnel to quantitatively evaluate a person's fitness for continued duty and thus assess the risks of failure that could result from sending a fatigued crew member on yet another mission.

To illustrate the assessment methodology, let us consider the detrimental effects of a sustained operations scenario. Let us assume that our mission plan calls for long-duration flights in single-seat tactical aircraft that will require the pilots to start their day at 0200 with a briefing and end at 2300 with a night carrier landing in poor weather. The mission is quite complex.

Hours of formation flying and several air-to-air refueling tasks are required to and from the combat zone. The mission contains several critical decision points at which the pilots must evaluate the tactical situation and make contingency modifications to the plan of attack based on quantitative target data that they must recall from the briefing they received hours before. For this mission, the operational staff has the technical information needed to predict aircraft and weapon system performance, but what do they have to estimate how the crews will perform in the later stages of the mission when fatigue becomes a significant factor? The AGARD battery of performance tests could be used to assess the stress effects of this kind of mission profile.

How does the operational staff get these data? The first step would be to query the AGARD STRES battery data base to see if anyone has already studied the effects of long-duration flights on crew performance. One of the objectives for standardization of human performance testing methodology is to provide a data base that could be accessed for operational planning. The data base should contain descriptive data on human performance under a wide variety of operationally relevant stressors. Research scientists throughout the NATO countries are accumulating data using the standardized battery of performance tests that are described in this lecture series. As the data bank grows, the probability increases that a particular operational stressor of interest will be covered. Even though the data base may not contain a report on a closely related mission profile, there may be significant trends in the collective results of many experiments, and these trends may allow a credible extrapolation for specific situations.

Keep in mind, the AGARD STRES battery is a set of tests that measure certain skills, abilities, and processes that are basic elements of human cognitive and psychomotor performance. These seven performance tests are applicable to a wide variety of military tasks. Judge the applicability of each of these seven tests to a particular set of military tasks. For example, if a user found evidence in the data bank that reaction time, memory search, and grammatical reasoning were seriously affected by the long-duration mission illustrated above, they could predict the crew members were incurring additional risks at the combat phase of the mission. Additional risk could also be predicted when returning and attempting to land on a carrier deck in rough seas and bad weather. In a broader sense, be very familiar with the critical tasks that each crew member performs, and estimate the extent to which these tasks are placed at risk by the pattern of performance decrements seen on the AGARD STRES battery. A specific pattern of performance decrements may slow completion time on one task with no significant mission effect but prevent completion on another task that is necessary for mission success. For example, a performance decrement in reaction time, spatial processing, and tracking may only slow the time to complete air-to-air refueling, but could mean the difference between success or failure in air-to-air combat.

Prepare to discuss these identified risks with the operational commanders who have the responsibility for deciding how much error can be tolerated on a particular task. In a training exercise, the commander may be willing to risk accuracy and delays in hitting the target, but in actual combat these deficits might cause loss of life and failure of the mission. He may evaluate the risk differently, depending on the importance of the mission. The commander will probably want a risk analysis of several operational plans that contains different patterns of performance decrements to be able to weigh the relative risks of each plan and present recommendations. The AGARD STRES battery data base should help you accomplish such tasks.

As stated before, knowledge of the critical tasks that the crew member performs during the mission is necessary. If you can not rely on personal knowledge, you should have access to a detailed description of the jobs, tasks, subtasks, and performance elements of each crew station that is critical for the anticipated mission. Ideally, these analyses should be organized in a relational data base, which would allow you to compare performance elements of the tasks with scores on the corresponding performance elements on the AGARD STRES battery. An alternate approach would be to identify those performance elements that are most likely to be affected by a deterioration of crew performance, and concentrate analysis on those elements.

If you cannot get sufficient information from the data base, you may need to simulate the mission stressors and expose several crews to those conditions while periodically measuring crew performance on the AGARD STRES battery. Military planners are accustomed to running mission simulations to make sure the timing and logistical support plans are realistic and do not contain some hidden surprise that would jeopardize the mission. Human performance should not be overlooked in such simulations. Crews having to make split-second judgments under the stress of combat and fatigue should not be expected to always make the same decision that a staff of seasoned veterans would make at a planning conference. Quantitative measures of human performance should be added to the simulations to assess the ability of crews to maintain an acceptable level of performance at critical points in the mission profile. In addition to estimating performance decrements that are likely to occur during a mission, flight surgeons are frequently faced with a difficult decision regarding a crew member's fitness for duty at the beginning of a mission. This question is more easily appreciated in the context of clinical situations in which a crew member has been recently treated for an illness, and either the disease or the treatment has had significant effects on his cognitive and motor performance. How much time is needed for complete recovery? All of us have experienced this situation, and we usually return to our office job even though we are not performing at our full potential. Aviators should not do that.

Flight surgeons need some efficient way to assess the aviator's fitness to return to flying duties. The AGARD STRES battery could provide valuable data to assist flight surgeons in making those decisions. A more difficult but related question is whether to remove someone from duty status in a nonclinical situation. It is sometimes difficult for a person to recognize their own incapacitation unless it is very severe. An experienced flight surgeon may suspect that an aviator should not be flying, but cannot prove it with routine clinical measurements. In such cases, the AGARD STRES battery could be an important addition to the flight surgeon's assessment battery.

Fitness for duty applications imply that the crew member's performance has deviated from some acceptable criteria. Unfortunately, the tests on the AGARD STRES battery require a crew member to learn a task and to develop a personal strategy for doing the task. During the learning period, the crew member's normal performance is unknown. Performance has to stabilize and a baseline be established before one can say that the crew member's performance has deviated significantly from his own baseline or from a population norm. The ideal situation would permit a crew member to complete the test battery frequently enough to establish a good baseline and a range of normal deviations. Performance below a certain level could then be established as a criteria for removal from duty. Without such a personal baseline, performance must be compared to population norms, which could be acquired from the data base.

I would like to end with a word of caution. Most military situations will contain many stressors. Each may affect performance independently of the others. The data base may contain data from research studies in which the effects of each stressor were evaluated independently of all the others. Do not assume that the reported effects of stressor "A" plus the reported effects of stressor "B" are equivalent to the combined effects of stressors "A" and "B." How are data that were gathered independently on only one stressor at a time used to predict the effects of many stressors applied simultaneously (as they are likely to be in real military situations)? We do not have the answer! Perhaps over a period of time, researchers will collect performance data in which their subjects are exposed to various combinations of stressors, and those data

will be added to the data base along with the data on the effects of independent stressors. We may then begin to understand the interaction of multiple stressors. Until then, you should use the best human performance data available, your own experience, and sound judgment.